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Decision Support System for Syndrome Differentiation in Traditional Chinese Medicine Based on Expert System

I.G.P. Asto Buditjahjanto
Department of Electrical Engineering, Universitas Negeri Surabaya,
Kampus Ketintang Surabaya, Indonesia

Abstract: Problems often arise in TCM is a problem of syndrome classification. Classification syndrome is one way to determine what action should be performed in the treatment of patients. In appropriateness in determining the syndrome can result in inhibition of the patient's recovery. The purpose of this research is to create a decision support system that can help in determining the syndrome in TCM. Decision support system can also be used as a medium of learning for students and people who learn about the syndrome in TCM. Decision support system is built by using the expert system that has the advantage in imitating the expertise of the expert.

Key words: Expert system, database, certainty factor, decision support system, traditional chinese medicine

INTRODUCTION

Decision Support System (DSS) has been widely used to help people in the decision making of the problems that they deal with. A DSS has some advantages in providing the best decision for its users. As in the banking sector which the problems are usually in the form of multicriteria problem by using the decision support system that combined with multicriteria analysis and fuzzy preference relation, then the problems can be solved (Gaspari *et al*., 2009; Rigopoulos *et al*., 2008). In the case of production management, DSS also can be used to reduce inventory costs by simultaneously considering ordering cost, ordering quantity, lead time and number of lots delivered from the vendor to the buyer (Lo, 2007).

Similarly, in the medical sector, DSS has been widely used as Management of Chronic Disease (Carson *et al*., 1998), for clinical and operational risk management (Cornalba *et al*., 2008) and provide significant and satisfactory results. DSS applications in medical typically is used to help diagnose a disease. Such as the research that conducted by Srinivasan *et al*. (2006) to create a DSS that uses clinical decision criteria based on expert knowledge to give advice to Paramedical and semi-skilled personnel to diagnose the etiology of neonatal jaundice. Some DSS's are used to improve clinical decision efficacy based on soft computing for breast cancer treatment (Skevofilakas *et al*., 2005; Najmeh *et al*., 2013) for the classification of types of cancer in human organs such as lung, heart (Titus *et al*., 2015; Priya *et al*., 2012; Rahulamathavan *et al*., 2014; Liu *et al*., 2016).

One of the type soft computing that usually used is an expert system. The expert system builds their knowledge based on the expert knowledge. Expert systems are widely used to solve some problems as well as in the medical field. As it is known, MYCIN is the early emergence of the use of expert systems. MYCIN was used to help doctors to prescribe drugs for blood Reviews such infectious. Beside that, expert systems have also been used to clinical diagnosis (Geng and Zhang, 2014), to help doctors to determine the type of diabetes (Lee and Wang, 2011), to scoring level of multiple sclerosis (Mauro *et al*., 2009), to give decision support for cardiopulmonary management and intensive care unit sedation (Gholami *et al*., 2012), to diagnose and treat pancreatic, thyroid and parathyroid gland diseases (Abu-Naser *et al*., 2010).

In Indonesia, Traditional Chinese Medicine (TCM) is growing as one of the treatments that are widely used by the people of Indonesia. The TCM treatments include acupuncture, herbs, acupressure, tuina. In studying TCM, the students will have problems in determining a syndrome of a disease because they have to identify the symptoms that appear from a patient. This stage is very important, if the students is not appropriate in determining the syndrome then the treatment will not be effective (Cheng *et al*., 2011). Determination of a disease syndrome is a difficult thing for students learn it. This is because it takes a lot of experience in observing the symptoms that appears from the patient (Das *et al*., 2013). Whereas, the process of gaining experience and observe will take a long time. Therefore, it requires an appropriate method to be able to assist in accelerating the

determination of a syndrome study. One method that can overcome this is an expert system that uses an expert expertise to respond the problem in determining the disease syndrome.

Learning through computer-based media will be more fun when compared to traditional ways. Media-based computer as a simulation will provides experience in studying a given subject matter (Buditjahjanto, 2013). So, it is with the use of DSS. DSS can also be used as a medium for computer-based simulation to study the process. By using simulation, the cost and time can be reduced when compared with the process of being directly and real (Buditjahjanto and Miyauchi, 2011). This research aims to a new approach by using the DSS-based expert system for determining a disease syndrome as well as make it easier for the students to determine the disease syndrome.

MATERIALS AND METHODS

Basic theory of Traditional Chinese Medicine (TCM): The use of TCM in the treatment has been widely used and increasingly recognized by people in the world, currently. The basic concept of TCM is to apply the theory of balance of Yin Yang, the five elements that represent elements in the earth that is wood, fire, earth, metal and water. The fifth element itself also represents an organ in the human body such as wood for the liver organ, fire for the heart organ, earth for the spleen organ, metal for lung organ and water for kidney organ.

Chunjiang (2005) states that a symptom is an external manifestation of a disease suppose that headache, fever, chills, hot. While a syndrome is considered a condition caused by the disease, its nature, the infected area and the relationship between the causes of disease and the energy contained within the patient. So, it can be interpreted that the syndrome has a range or a broader view and a thorough review of a disease. As an illustration, the following is an example if the patient has a clinical complaint such as fever, a little heat, headache, body aches, do not sweat and pulse float, then the disease is caused by a cold wind, its location on the surface, the nature of the disease and its relationship with the cold Qi factors are excess, then it can be concluded external excess syndrome. The determination of the syndrome is to help facilitate the determination of therapy. The concern generally covers the entire process of pathological diseases while syndrome only describes the stages of the disease. Therefore, a disease may show different syndromes and different diseases may also have the same syndrome. Determination or classification of TCM syndrome consists of Cheng *et al*. (2011): syndrome classification based Chunjiang (2005) organ abnormalities. Chunjiang (2005) organs include: lungs, heart, spleen, kidneys and liver. Fu organs include: large intestine, small intestine, stomach, bladder and gallbladder. The classification is based on abnormalities meridian syndrome include: reactions to emphasis, abnormalities in the smooth flow of Qi in the meridians, abnormalities in the direction of the flow of Qi in the meridians. Syndrome classification based on 6 meridians. The meridians are: Tay Yang meridian, meridian Sao Yang, Yang Ming meridian, meridian Cie Yin, meridian Sao Yin and Tay Yin meridians, d. Syndrome classification based Ying, Wei, Qi and Sie, e. Syndrome classification based San Ciao.

Expert system: An expert system is a computer program that represents or replace an expert that has knowledge of specialist subject in order to solve problem (Jackson, 1999). The characteristics of an expert system are: it can imitate human reasoning about a problem in a certain domain, it undertakes reasoning over representations of human, knowledge and data retrieval and it solves problems by approximate methods or heuristic methods. The advantages of using an expert system are as follows: storing and provide expertise at all times in various locations, working process or routine tasks that require an expert, having the ability to access knowledge, increasing the capability to solve problems, saving time in decision making.

Structure of expert system: Knowledge of an expert system is represented in the form of the type of rule IF and then. The basic concept of an expert system contains some elements as follows (Robert *et al*., 1991). User interface that is used by the user and expert systems to communicate. Knowledge Base that contains the knowledge-knowledge in solving problems in a particular domain. Knowledge acquisition that transfers, accumulates and transforms expertise in solving the problem of the sources of knowledge into a computer program. Inference engine, software that performs reasoning using existing knowledge to produce a conclusion or the final outcome. Improvement of knowledge, the experts have the ability to analyze and improve the performance and the ability to learn and performance.

Certainty factor: Turban (2005) states that the certainty factor is the belief in an event can be a fact or hypothesis based on evidence or expert judgment. Certainty Factor (CF) using a value to capture the degree of belief an expert to the data. CF is based on the concept of belief and unbelief are formulated in the form of the following equation:

$$CF(H, E) = MB(H, E) - MD(H, E) \quad (1)$$

Where:

CF(H, E) = Certainty Factor

MB(H, E) = Measure of Increased belief of the hypothesis H that if given evidence E (between 0 and 1)

MD(H, E) = Measure of Increased disbelief toward evidence-H, if given evidence E (between 0 and 1)

The basic form of formula CF in the form of a rule IF E THEN H is as shown in the following equation:

$$CF(H, e) = CF(E, e) \times CF(H, E) \quad (2)$$

Where:

CF(E, e) = CF evidence E is influenced by evidence e

CF(H, E) = CF hypothesis assuming the evidence is known with certainty, i.e., when the CF(E, e) = 1

CF(H, e) = CF hypothesis is influenced by evidence e

If all the evidence in the antecedent is known for certain, the equation becomes:

$$CF(H, e) = CF(H, E) \quad (3)$$

Rule with the same conclusion: In the process of rule execution, it could be happened that those rules can produce the same hypothesis or conclusion. Therefore, there must be a mechanism for combining some hypotheses into a single hypothesis. The equation for combining two CF is as follows:

$$CF_{combination}(CF_{old}, CF_{new}) = \begin{cases} CF_{old} + CF_{new}(1 - CF_{old}) \text{ both} > 0 \\ CF_{old} + CF_{new}(1 + CF_{old}) \text{ both} < 0 \\ \dfrac{CF_{old} + CF_{new}}{1 - \min(|CF_{old}|, |CF_{new}|)} \end{cases} \quad (4)$$

The research consists of three stages such as data collection stage, expert system stage and decision stage as seen in Fig. 1. The first stage is data collection. The form of the data is weights of expert preference. The weights are obtained through the judgement of expert preference by assessing syndrome of Zang Fu organ versus clinical manifestations (symptoms). As mentioned before that in this research the selection syndrome differentiation is based on theory Zang Fu organ (Cheng *et al*., 2011). Zang Fu organs consist of organs as follows: Lung (L), Large Intestine (LI), Spleen (Sp), Stomach (St), Heart (Ht), Small Intestine (SI), Kidney (K), Blader (Bl), Triple Burner (TB) and Liver (L). In detail each organ has some syndromes such as: lung organ has five syndromes, large intestine organ has five syndromes, spleen organ has three syndromes, stomach organ has four syndromes, heart organ has five syndromes, small intestine organ has three syndromes, kidney organ has two syndromes, blader organ has two syndromes, triple burner organ has two syndromes and liver organ has eight syndromes.

The instrument has been made in order to collect data. Table 1 is an example one of the instruments that is used to collect weight of expert preference. The lung organ with the syndrome: invasion of the lungs by wind cold is shown in Table 1. The expert fills the value of weight based his preferences with the range of weight values is between 0 until 1. For example, the expert gives the weight value as 0.7 for headache (symptom) so this value is degree of believing the expert for headache on lung organ with syndrome type invasion of the lungs by wind cold.

Next stage is to build expert systems. At first, the weight value of expert preference is converted as a certainty factor value in the database. This value is selected when patient select the clinical manifestation (symptom) in the user input application. The design of the database can be shown at Fig. 2. ERD Expert System for selection syndrome differentiation. This ERD connects multiple tables such as physician table, symptom consulting table, diagnosis tables, patient table, symptom table, CF expert table, consulting tables, organ table, syndrome consultation table and syndrome table. Each table is associated with other table through a relation. The type of relations are such as: one-to-many relation, one-to-one relation and many-to-one relation. An example of the relation in this DSS is as follows: physician table connects to CF Expert with one-to-many relation in order to each doctor can give his preference value to the CF table. Furthermore, CF table is linked to a syndrome table with many-to-one relation where the syndrome table is also associated with organ table with one-to-many relation. And then, syndrome table is connected with the consultation table with one-to-many relation. Symptom table is formed by two tables. The first table is a consultation table that connected in many-to-one relation and the second table is a CF expert table than connected in many-to-one. Next, this symptom table is linked to diagnosis table in one-to-many relation. Consultancy table is formed from two tables, there is diagnosis table in many-to-one and a syndrome consultation table in a many-to-one relationship. The last table is patient table

Table 1: Instrumen to obtain weight value of expert preference

Lung syndrome	Clinical manifestation								
Invasion of the lungs by wind cold	Severe chills	Slight fever	Headache	General aching	Absence of sweat	Nasal discharge	Cough with clear, thin sputum	White tongue coating	Superficial and tense pulse
Weight of expert preference	(.....)	(.....)	(.....)	(.....)	(.....)	(.....)	(.....)	(.....)	(.....)

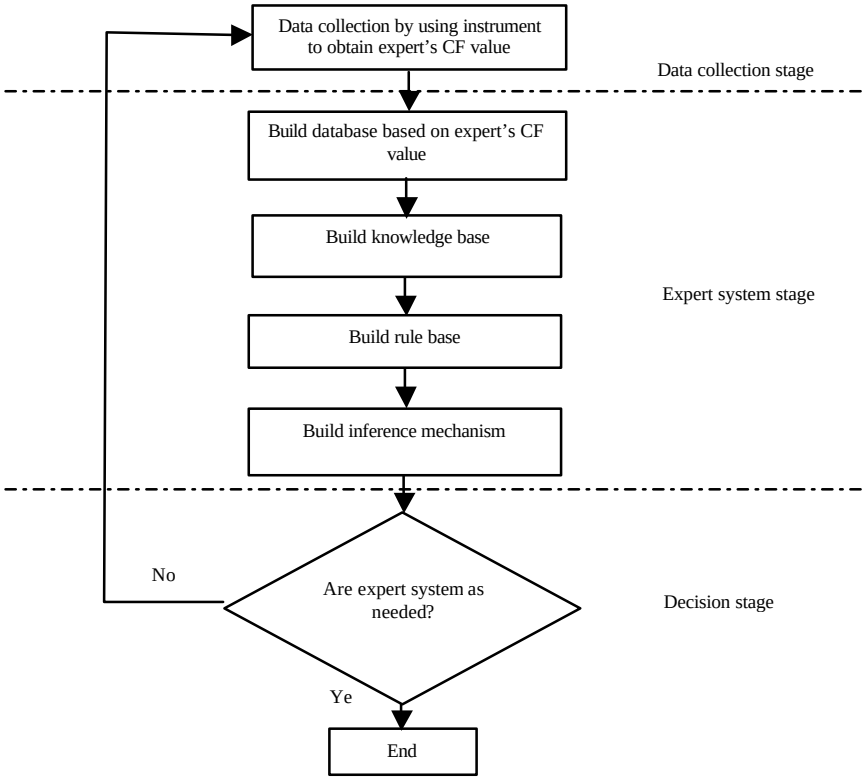


Fig. 1: Block diagram of expert system

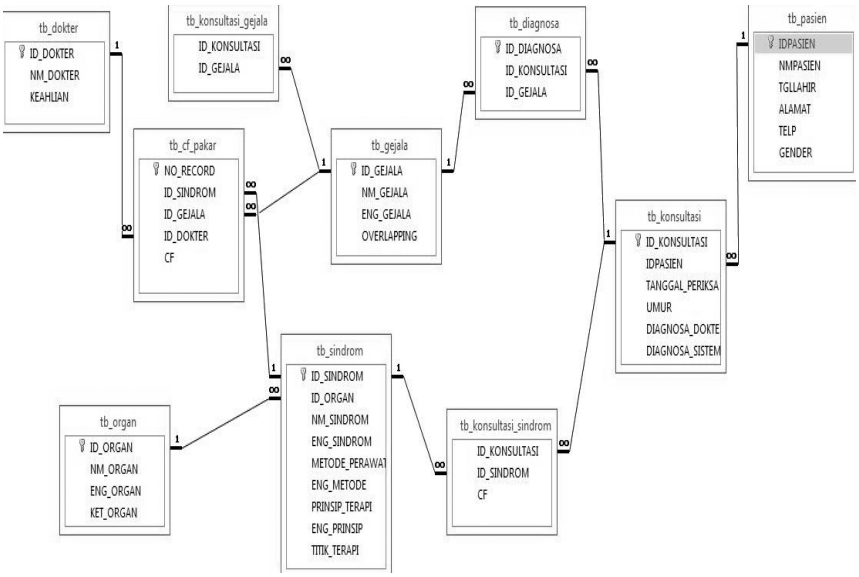


Fig. 2: ERD of TCM expert system

that is linked to the consultation table in many-to-one relation. These relations are formed according to the design of DSS.

Knowledge base system for this decision support system is based on an instrument. Knowledge is built by arranging relation Zang Fu organ versus clinical manifestation of the syndrome. Rule base is built also based on the instrument for Zang Fu organ with clinical manifestation of all syndromes. Inference mechanism is constructed to connect the selected symptoms by the user and provide answers in the form of the CF value of the selected syndrome symptoms.

At the decision stage, the DSS sorts the CF total value of each syndrome and shows the tenth highest of the CF total values. In this stage, testing is done by entering the data from the patient's status obtained from AAS (Academy of Acupuncture Surabaya) to test whether the results are the same as that of the status of these patients. The status of these patients is a sheet filled out by the patient's final year as a prerequisite for graduation. The results of the patient's status assessed by the lecturer on the subject. If simulation result is less appropriate, then it requires improvements starting from the data collection until the inference mechanism. However, if the result is appropriate, the expert system application program is acceptable.

RESULTS AND DISCUSSION

Knowledge base system: The view of the knowledge base is shown in Fig. 3. In this Fig. 3 consists of four columns. The first column is ID_GEJALA which becomes the primary key of this table. The second column shows the symptoms in terms of Indonesian, third column explains the symptoms in terms of the English language. And the fourth column describes the location of symptoms of the organ. In this study, the user can edit symptoms of the entire syndrome Zang Fu organs.

Figure 4 shows the display of knowledge base that is used to input some data, such as ids syndrome, its symptoms, ids physician (expert) and CF value. Three experts from AAS (Academy of Acupuncture Surabaya) collaborate in this research. Their preference toward the symptoms of each syndromes are used as weight (CF value) for knowledge base. Our knowledge base capable to use more than one preference of the experts. The purpose of this capability is to reduce the bias level from the preference of the experts.

Rule base: Figure 5 and 6 shows the display to edit and add new the data syndrome. The edit button is used to update the data in an existing syndrome. The function of edit button is to edit: the name of the syndrome, syndrome id, name syndrome, treatment principles and treatment point. The result of editing can be seen on display beneath which consists of six columns. The first column is the ID syndrome that becomes the primary key of the table. The second column describes the syndrome in terms Indonesian, the third column shows the syndrome in terms English. The next, fourth column describes the ID organs showing the location symptoms to organs. The fifth column shows the method of treatment in terms Indonesian while the sixth column shows the method of treatment in terms English.

So, does with the button of new with the function is to add: the name of the syndrome, syndrome id, name syndrome, treatment principles and treatment point. The result of the using of button new can be seen on display beneath which consists of six columns. The first column is the ID syndrome that becomes the primary key of the table. The second column describes the syndrome in terms Indonesian, the third column shows the syndrome in terms English. The next, fourth column describes the ID organs showing the location symptoms to organs. The fifth column shows the method of treatment in terms Indonesian while the sixth column shows the method of treatment in terms English.

Inference system: Figure 7 shows the inference mechanism of the expert system to diagnose a syndrome. The explanation to define a syndrome is as follows: the user inputs the patient data. After that, the user selects the presenting symptoms in patients based on complaints that arise. Preferably, if the symptoms are selected more than one. It is intended in order to the inference system can run properly for calculating the total value of the CF syndrome. Therefore, a user should be capable to explore the symptoms that could appear from the patient's complaints. Incompatibility in inserting symptoms may also affect the results of the determination of the syndrome. Further more, after entering all the symptoms of the patient. The calculate button is used to calculate the total value of the CF from a syndrome based on the symptoms that have been selected. The results of the calculation of the total value of CF appear in ten consecutive syndromes. Syndromes are shown starting from the highest value of the total CF toward to the lowest value of the total CF. On display is also shown the recommendation for patient diagnosis, treatment methods, principles of treatment and acupuncture points for treatment. The recommendation is only for the syndrome that have the highest of the total value of CF.

For example, in Fig. 7, the user selects the symptoms that the patient has been complaining as follows: id_symptom 6 (cough with yellow and sticky sputum),

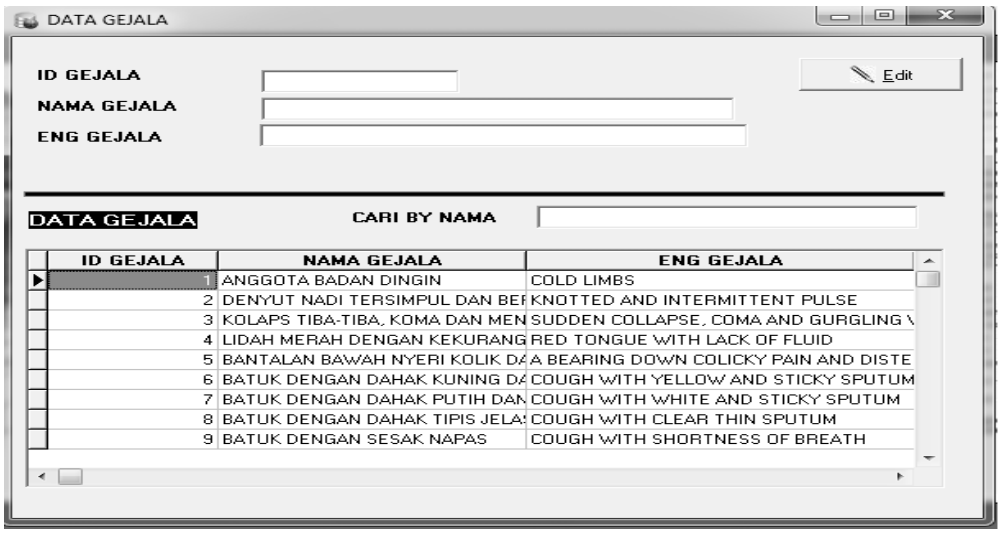


Fig. 3: Display to edit symptoms

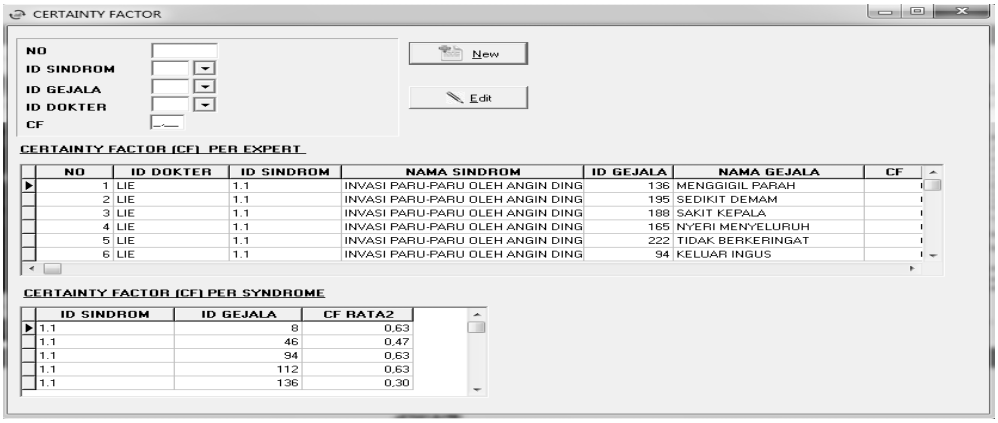


Fig. 4: Display of CF value

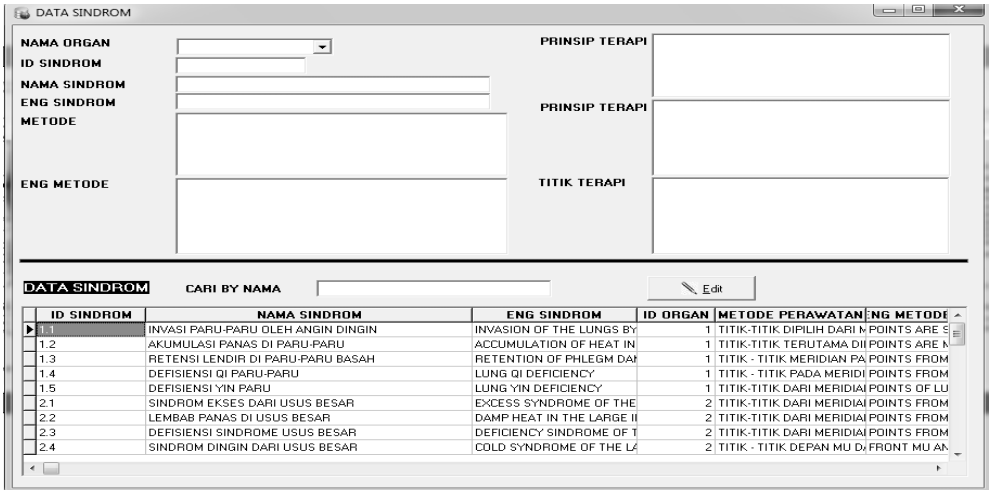


Fig. 5: Display to edit and add rule base

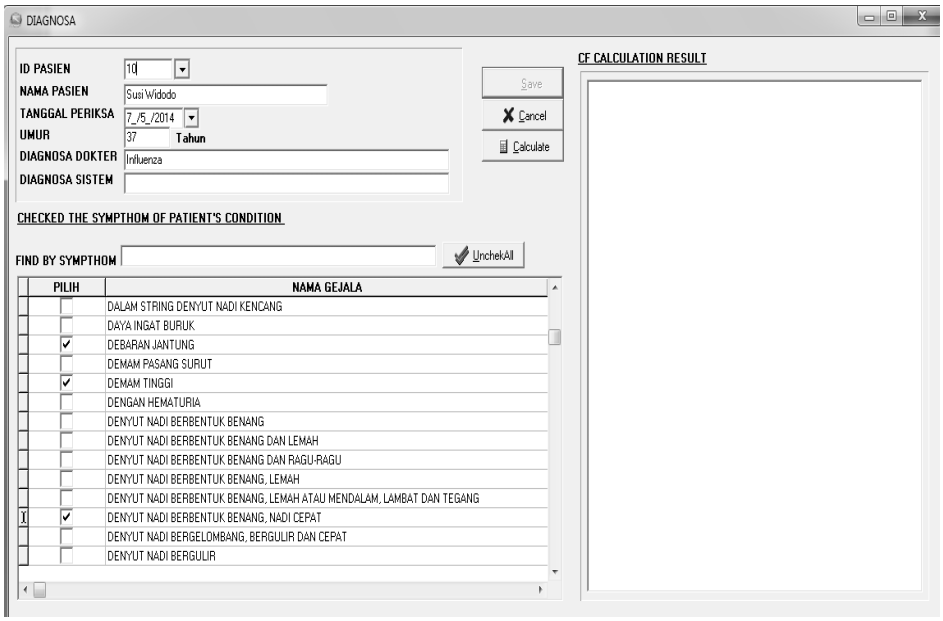


Fig. 6: Display to diagnose the syndrome

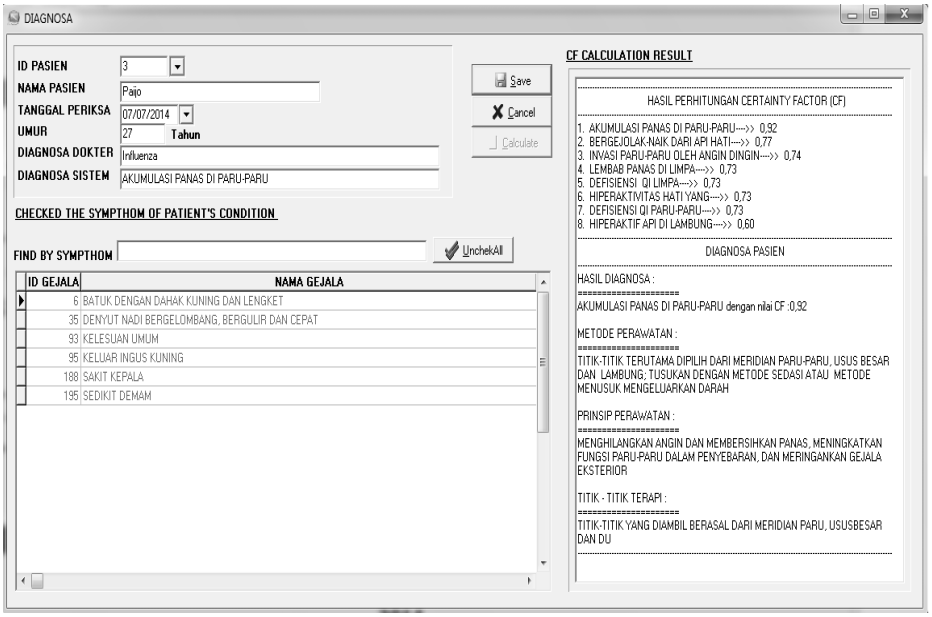
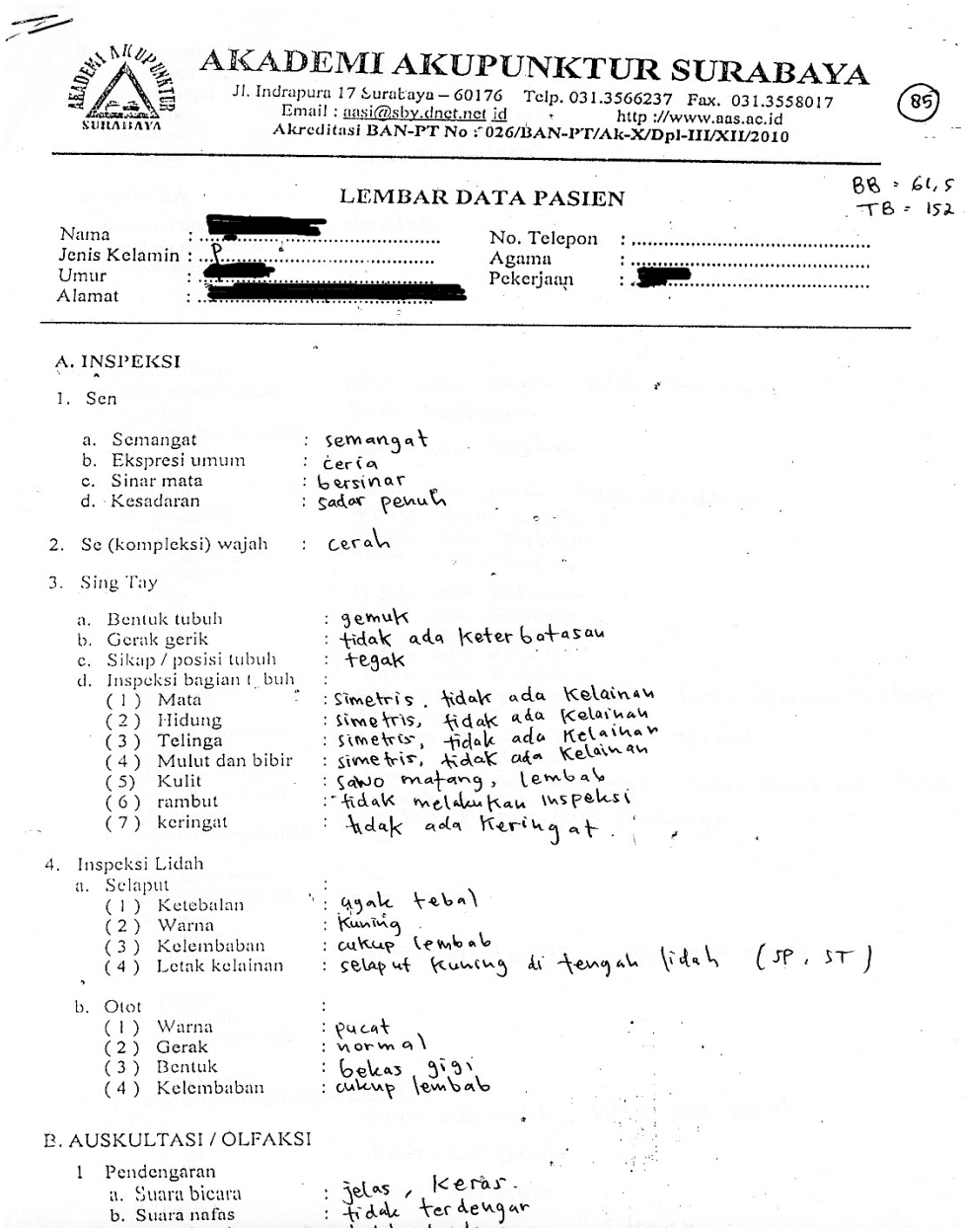


Fig. 7: Display of inference system to diagnose a syndrome

id_symptom 35 (a surging, rolling and rapid pulse), id_symptom 93 (general lassitude), id_symptom 95 (yellow nasal discharge), id_symptom 188 (headache) and id_symptom 195 (slight fever). Then press the calculate button to perform the calculation of the total value of CF. The calculation result is shown in a sequence of ten syndromes. Syndrome "accumulation of heat in the lungs" has the highest value of the total CF.

Testing of decision support system based on expert system: Tests carried out using data from the Academy of Acupuncture Surabaya (AAS). The data were in the form of patient data sheet that was taken when patients go to the clinic in AAS to get medical treatment. Patient data sheets are the results of the examination of the AAS students as the final exam practice materials to observe the patient and determine the TCM syndrome. Figure 8 shows a patient data sheet of AAS.



AKADEMI AKUPUNKTUR SURABAYA

Jl. Indrapura 17 Surabaya – 60176 Telp. 031.3566237 Fax. 031.3558017
Email : aasi@sby.dnet.net id http ://www.aas.ac.id
Akreditasi BAN-PT No : 026/BAN-PT/Ak-X/Dpl-III/XII/2010

85

BB = 61,5
TB = 152

LEMBAR DATA PASIEN

Nama : [redacted] No. Telepon : .....
Jenis Kelamin : P Agama : .....
Umur : [redacted] Pekerjaan : [redacted]
Alamat : [redacted]

A. INSPEKSI

1. Sen
   a. Semangat : semangat
   b. Ekspresi umum : ceria
   c. Sinar mata : bersinar
   d. Kesadaran : sadar penuh
2. Se (kompleksi) wajah : cerah
3. Sing Tay
   a. Bentuk tubuh : gemuk
   b. Gerak gerik : tidak ada keterbatasan
   c. Sikap / posisi tubuh : tegak
   d. Inspeksi bagian t buh :
      (1) Mata : simetris, tidak ada kelainan
      (2) Hidung : simetris, tidak ada kelainan
      (3) Telinga : simetris, tidak ada kelainan
      (4) Mulut dan bibir : simetris, tidak ada kelainan
      (5) Kulit : sawo matang, lembab
      (6) rambut : tidak melakukan inspeksi
      (7) keringat : tidak ada keringat
4. Inspeksi Lidah
   a. Selaput :
      (1) Ketebalan : agak tebal
      (2) Warna : kuning
      (3) Kelembaban : cukup lembab
      (4) Letak kelainan : selaput kuning di tengah lidah (SP, ST)
   b. Otot :
      (1) Warna : pucat
      (2) Gerak : normal
      (3) Bentuk : bekas gigi
      (4) Kelembaban : cukup lembab

B. AUSKULTASI / OLFAKSI

1 Pendengaran
   a. Suara bicara : jelas, keras.
   b. Suara nafas : tidak terdengar

Fig. 8: Patient data sheet of AAS

In this research, testing used 30 data of patients. The procedure of simulation was as follows: researcher selected symptoms that appear from the patient data sheet by clicking the symptom on display as seen in Fig. 6. After that, calculate button was clicked in order to obtain a diagnosis of a syndrome. This procedure was repeated to obtain diagnostic of syndrome of each patient until the 30th data. The simulation results showed that 24 diagnostics from students (patient data sheets) match with the simulation result and 6 diagnostics from students did not match with simulation results. There were some different results between diagnostic of students and expert system simulation. It was happening because score from the teacher/expert for student's patient data sheets were less than or equal to 65. Therefore, the accuracy to determined of syndrome less accurate. In contrary, if score from the teacher/expert for student's patient data sheets were greater than or equal to 70 then the simulation results and diagnoses of students were the same. Table 2 shows the results of testing between diagnosis of students versus expert system.

Table 2: The comparison of testing results between diagnostic of students versus expert system

		Similar	
Patient data sheets (score from teacher/expert)	DSS application	Yes	No
Heart Qi deficiency (75)	Heart Qi deficiency	✓	
Liver Qi stagnation (60)	Stirring of liver wind in the interior	✓	
Hyperactivity of fire in the stomach (75)	Hyperactivity of fire in the stomach	✓	
Retention of phlegm damp in the lungs (60)	Consumption of the fluid of the large intestine		✓
Heart Qi deficiency (70)	Heart Qi deficiency	✓	
Spleen Qi deficiency (70)	Spleen Qi deficiency	✓	
Spleen Qi deficiency (65)	Hyperactivity of fire in the stomach		✓
Excess cold in the stomach (80)	Excess cold in the stomach	✓	
Hyperactivity of liver yang (80)	Hyperactivity of liver yang	✓	
Flare up of the liver fire (80)	Flare Up of the liver fire	✓	
Liver Qi stagnation (80)	Liver Qi stagnation	✓	
Liver blood deficiency (80)	Liver blood deficiency	✓	
Hyperactivity of liver yang (80)	Hyperactivity of liver yang	✓	
Hyperactivity of liver yang (80)	Hyperactivity of liver yang	✓	
Kidney yin deficiency (80)	Kidney yin deficiency	✓	
Spleen Qi deficiency (80)	Spleen Qi deficiency	✓	
Kidney Yin deficiency (60)	Lungs Yin deficiency		✓
Heart Qi deficiency (70)	Heart Qi deficiency	✓	
Spleen Qi deficiency (85)	Spleen Qi deficiency	✓	
Liver Qi stagnation (75)	Liver Qi stagnation	✓	
Lung Qi deficiency (80)	Lung Qi deficiency	✓	
Liver Qi stagnation (75)	Liver Qi stagnation	✓	
Spleen Qi deficiency (80)	Spleen Qi deficiency	✓	
Liver Qi stagnation (80)	Liver Qi stagnation	✓	
Hyperactivity of fire in the stomach (65)	Kidney yin deficiency		✓
Hyperactivity of fire in the stomach (70)	Hyperactivity of fire in the stomach	✓	
Liver Qi stagnation (80)	Liver Qi stagnation	✓	
Lungs Qi deficiency (75)	Lungs Qi deficiency	✓	
Liver Qi stagnation (75)	Liver Qi stagnation	✓	
Liver Qi stagnation (65)	Spleen Qi deficiency		✓

CONCLUSION

System development and implementation of decision support system by using the expert system can be used to assist in determining the syndrome in TCM. Preference of expert toward symptoms from each syndrome in Zang Fu organs can be used as the CF value of expert system. Further more, the symptoms are selected by the user/student is calculated to determine the value of CF total. The highest of value of CF total determines syndrome. The results showed that DSS has been able to determine precisely the TCM syndrome. By using the data of 30 patients taken from the student diagnosis (patient the data sheets) there are only 4 imprecise syndromes while 26 others are precisely.

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